It would be easy to extend our notice on the animal forms alluded to, but our space forbids. It is curious that no vegetable life seems to have been met with in depths below 100 fathoms. "No plants live, so far as we know, at great depths in the sea; and it is in all probability essentially inconsistent with their nature and mode of nutrition that they should do so." But parasitic alga have been detected in some of the deep-sea corals, and we are a little surprised to see the position of the diatoms queried; surely their plant affinities cannot now be discussed, and without these little plants we fancy some of the plant-eating deep-sea forms of animal life would be badly off. Holothuroids are especially fond of them.

The following general conclusions are arrived at:—

"1. Animal life is present on the bottom of the ocean at all depths.

"2. Animal life is not nearly so abundant at extreme as it is at more moderate depths; but, as well-developed members of all the marine invertebrate classes occur at all depths, this appears to depend more upon certain causes affecting the composition of the bottom deposits, and of the bottom water involving the supply of oxygen, and of carbonate of lime, phosphate of lime, and other materials necessary for their development, than upon any of the conditions immediately connected with depth.

"3. There is every reason to believe that the fauna of deep water is confined principally to two belts, one at and near the surface, and the other on and near the bottom; leaving an intermediate zone in which the larger animal forms, vertebrate and invertebrate, are nearly or entirely absent.

"4. Although all the principal marine invertebrate groups are represented in the abyssal fauna, the relative proportion in which they occur is peculiar. Thus Mollusca in all their classes, Brachyourous Crustacea, and Annelida, are on the whole scarce; while Echinodermata and Porifera greatly preponderate.

"5. Depths beyond 500 fathoms are inhabited throughout the world by a fauna which presents generally the same features throughout; deep-sea genera have usually a cosmopolitan extension, while species are either universally distributed, or, if they differ in remote localities, they are markedly representative, that is to say, they bear to one another a close genetic relation.

"6. The abyssal fauna is certainly more nearly related than the fauna of shallower water to the faunæ of the tertiary and secondary periods, although this relation is not so close as we were at first inclined to expect, and only a comparatively small number of types supposed to have become extinct have yet been discovered.

"7. The most characteristic abyssal forms, and those which are most nearly related to extinct types, seem to occur in greatest abundance and of largest size in the southern ocean; and the general character of the faunæ of the Atlantic and of the Pacific gives the impression that the migration of species has taken place in a northerly direction, that is to say, in a direction corresponding with the movement of the cold under-current.

"8. The general character of the abyssal fauna resembles most that of the shallower water of high northern and southern latitudes, no doubt because the conditions of temperature, on which the distribution of animals mainly depends, are nearly similar."

These volumes form a distinct contribution to Science, and will certainly be welcomed by the scientific worker; and their interest to the general reader, who can pass over the few technical descriptions of the new forms, will be scarcely at all less.

THE MODERN TELESCOPE[1]

III.

WE know that both with object-glasses and reflectors a certain amount of light is lost by imperfect reflection in the one case, and by reflection from the surfaces and absorption in the other; and in reflectors we have generally two reflections instead of one. This loss is to the distinct disadvantage of the reflector, and it has been stated by authorities on the subject, that, light for light, if we use a reflector, we must make the aperture twice as large as that of a refractor in order to make up for the loss of light due to reflection. But Dr. Robinson thinks that this is an extreme estimate; and with reference to the four-foot reflector now in operation at Melbourne, and of which mention has already been made, he considers that a refractor of 33·73 inches aperture would be probably something like its equivalent if the glass were perfectly transparent, which is not the case.

On the assumption, therefore, that no light is lost in transmission through the object-glass, Dr. Robinson estimates that the apertures of a refractor and a reflector of the Newtonian construction must bear the relation to each other of 1 to 1·42. In small refractors the light absorbed by the glass is small, and therefore this ratio holds approximately good, but we see from the example just quoted how more nearly equal the ratio becomes on an increase of aperture, until at a certain limit the refractor, aperture for aperture, is surpassed by its rival, supposing Dr. Robinson's estimate to be correct. But with specula of silvered glass the reflective power is much higher than that of speculum metal; the silvered glass being estimated to reflect about 90 per cent.[1] of the incident light, while speculum metal is estimated to reflect about 63 per cent.; but be these figures correct or not, the silvered surface has undoubtedly the greater reflective power; and, according to Sir J. Herschel, a reflector of the Newtonian construction utilises about seven-eighths of the light that a refractor would do.

In treating of the question of the future of the telescope, we are liable to encroach on the domain of opinion, and go beyond the facts vouched for by evidence, but there are certain guiding principles which are well worthy of consideration. These have lately been discussed by Mr. Howard Grubb in a paper "On Great Telescopes of the Future." We shall take up his points *seriatim,* premising that in the two classes of telescopes, refractors and reflectors, each possesses some advantages over the other.

We may conveniently consider first the advantages which the refractor has over the reflector.

First, there is less loss of light with the former than with the latter, *as a rule,* hence for equal "space-penetrating power" the aperture of the reflector must be greater. This condition gives us a greater column of air and consequently greater atmospheric disturbance.

"The refractor having a tube closed at both ends, and the reflector being open at the upper end, the condition of air-currents is quite different in the two cases, to the disadvantage of the reflector, for in it the upper end being open, there is nothing to prevent currents of hot and cold air up and down the tube, and in and out of the aperture, and for this reason great advantage has been

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[1] Continued from p. 127.

[1] Sir John Herschel, in his work on the telescope, gives the following table of reflective powers:—

After transmission through one surface of glass not in contact with any other surface	0·957
After transmission through one common surface of two glasses cemented together	1·000
After reflection on polished speculum metal at a perpendicular incidence	0·632
After reflection on polished speculum metal at 45° obliquity...	0·690
After reflection on pure polished silver at a perpendicular incidence	0·905
After reflection on pure polished silver at 45° obliquity ...	0·910
After reflection on glass (external) at a perpendicular incidence	0·043

The effective light in reflectors (irrespective of the eye-pieces) is as follows:—

Herschelian (Lord Rosse's speculum metal)	A. 0·632
Newtonian (both mirrors ditto)	B. 0·436
Do (small mirror or glass prism)...	C. 0·632
Gregorian or Cassegrain	D. 0·399
The same telescopes, all the metallic reflections being from pure silver	A. 0·905 B. 0·824 C. 0·905 D. 0·819

found in ventilating the tubes, *i.e.* making it of some open-work construction, in order that the air may pass through and across and remove currents of differing temperatures. This difficulty is not felt with refractors; but, curious to say, in the largest refractor at present in existence (the Washington 26-inch), Prof. Newcomb informs me that considerable inconvenience is felt sometimes from the outside of the object-glass cooling down more quickly in the evening than the inside, which produces a decided effect on the spherical aberration, and injures temporarily the otherwise fine definition. He consequently recommends the use of lattice or ventilated tubes for very large refractors. If this be found necessary, this advantage of the refractor vanishes."

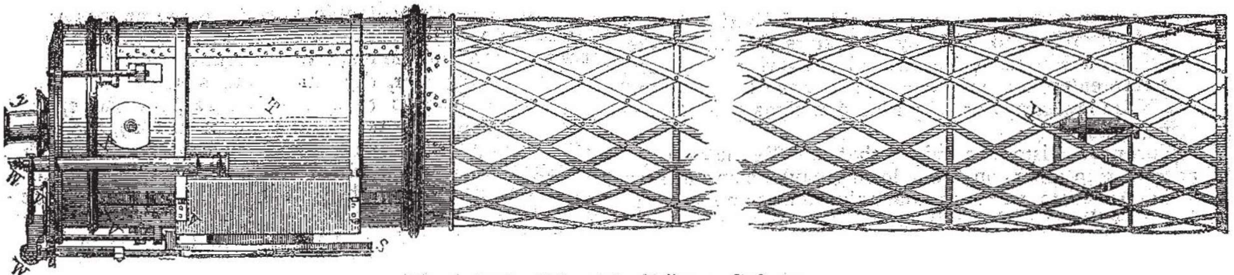

FIG 9.—Lattice Tube of the Melbourne Reflector.

But there is another nice point concerning this larger aperture which has to be considered.

We may set out with observing that the light-grasping power of the reflector varies as the square of the aperture multiplied by a certain fraction representing the proportion of the amount of reflected light to that of the total incident rays. On the other hand the power of the refractor varies as the square of the aperture multiplied by a certain fraction representing the proportion of transmitted light to that of the total incident rays. Now in the case of the reflector the reflecting power of each unit of surface is constant whatever be the size of the mirror, but in that of the refractor *the transmitting power decreases with the thickness of the glass*, rendered requisite by increased size. Although for small apertures the transmitting power of the refractor is greater than the reflecting power of the reflector, still it is obvious that on increasing the size a stage must be at last reached when the two rivals become equal to each other. This limit has been estimated by Dr. Robinson to be 35·435 inches, a size not yet reached by our opticians by some ten inches, but object-glasses are increasing inch by inch, and it would be rash to say that this size cannot be reached within perhaps the lifetime of our present workers. However this may be we can say with safety that up to the present limit of size produced, refractors have the advantage in light-grasping power, and it is also a question whether with increase of thickness in the glass there will not be such an increase in the purity of material and polish as to keep the loss by transmission at its present value. Any one who has a Tully and a Cooke object-glass, by placing them side by side on a clean sheet of paper, will be able to see how our modern opticians have already reduced the loss by transmission.

The next point worthy of attention is the question of permanence of optical qualities. Here the refractor undoubtedly has the advantage. It is true that the flint glass of some object-glasses, chiefly those produced in Germany, gets attacked by a sort of tarnish, still that is not the case generally, while on the other hand, metallic mirrors often become considerably dimmed after a few months of use, the air of a town seeming to be fatal to them, and although repolishing is not a matter of any great difficulty in the hands of the maker, still it is a serious drawback to be obliged to return mirrors for this purpose. There are, however, some exceptions to this, for there are many small mirrors in existence whose polish is good after many years of continuous use, just as on the other hand there are many object-glasses whose polish has suffered in a few years, but these are exceptions to the rule. The same remarks apply to the silvered glass reflectors, for although the silvering of small mirrors is not a difficult process, the matter becomes exceedingly difficult with large surfaces, and indeed at present large discs of glass, say of four or six feet diameter, can rarely be produced. If, however, a process should be discovered of manufacturing these discs satisfactorily and of silvering them, there are objections to them on the grounds of the bad conductivity of glass, whereby changes of temperature alter the curvature, and there is also a great tendency for dew to be deposited on the surface.

With regard to the general suitability for observatory work this depends upon the kind of work required, whether for measuring positions, as in the case of the transit instrument, where permanency of mounting is of great importance, or for physical astronomy, when a steady image for a time only is required. For the first purpose the refractor has decidedly the advantage, as the object-glass can be fixed very nearly immovably in its cell, whereas its rival must of necessity, at least with present appliances, have a small, yet in comparison considerable, motion.

The difficulty of mounting mirrors, even of large size, has now been got over very perfectly. This difficulty does not occur in the mounting of object-glasses of sizes at present in use, but when we come to deal with lenses of some thirty inches diameter, the present simple method will in all probability be found insufficient, but we anticipate that one will be adopted which will allow the permanent position of the object-glass to be retained.

J. NORMAN LOCKYER

(*To be continued.*)

OUR ASTRONOMICAL COLUMN

THE COMET OF 1106.—In Mr. Williams's account of the object observed by the Chinese in this year, and called a comet by Ma Twan Lin, we find the following note:—"This appears to have been a large meteor, as it seems to have been seen for a short time only." It is probable that the author had not compared Pingré's description of the motion of the comet, which was certainly observed in Europe early in the year, or he would have seen that in all likelihood, notwithstanding Ma Twan Lin's account reads as if it referred to a temporary phenomenon, the Chinese really observed the bright comet recorded by the European historians. We are told that in the fifth year of the epoch Tsung Ning, on day Woo Seuh of the first moon (1106, Feb. 10) a